

# DUPLEXER, AND LAMINATE-TYPE HIGH-FREQUENCY DEVICE AND COMMUNICATION EQUIPMENT USING THE SAME

## BACKGROUND OF THE INVENTION

### 5 1. Field of the Invention

The present invention relates to a duplexer, and a laminate-type high-frequency device and communication equipment provided with the duplexer. More specifically, the present invention relates to an antenna duplexer sharing one antenna on a transmitting side and a receiving side and separating a transmitted signal and a received signal from each other, and a laminate-type high-frequency device and communication equipment provided with the antenna duplexer.

### 2. Description of the Related Art

15 In an antenna duplexer sharing one antenna on a transmitting side and a receiving side, and separating a transmitted signal and a received signal from each other, two filters having different center frequencies are connected. Therefore, it is required that, at a center frequency of one of the two filters, the impedance of the other filter seen from an antenna that is an input/output terminal shared by the two filters is set to be infinite, whereby the transmission characteristics of the one of the two filters are prevented from being impaired.

For this purpose, a duplexer as shown in FIG. 24 is proposed (e.g., see pages 4–5 and FIG. 3 in JP 3,204,753). FIG. 24 is an exploded perspective view of the duplexer in the prior art.

As shown in FIG. 24, a first end ground electrode (not shown) is provided on a lower surface of a dielectric layer 11p. Furthermore, a through-hole 91p for connecting the first end ground electrode to a tip portion of a transmission line 70p (described later) is formed in the dielectric layer 11p.

On an upper surface of a dielectric layer 14p, resonant elements 21p, 22p, 23p, 24p, and 25p are provided, each having one end that is connected to the first end ground electrode, respectively, to form a 1/4 wavelength stripline resonator. Furthermore, on the upper surface of the dielectric layer 14p, electrodes 31p, 32p, 33p, 34p, and 35p are provided, each having one end that is connected to the first end ground electrode, respectively, and the other end that is opposed to open ends of the resonant elements 21p, 22p, 23p, 24p, and

25p, respectively, with a predetermined gap. A filter 500p in a comb-line shape is configured by using the distribution coupling of the resonant elements 21p and 22p, and a filter 600p in a comb-line shape is configured by using the distribution coupling of the resonant elements 23p, 24p, and 25p.

5 Furthermore, on the upper surface of the dielectric layer 14p, the transmission line 70p for constituting an inductor between the resonant elements 22p and 23p is provided. A through-hole 94p is formed at the tip portion of the transmission line 70 so as to be connected to the first end ground electrode.

10 On an upper surface of a dielectric layer 12p, an inner layer ground electrode 81p positioned on an open end side of the resonant elements 21p and 22p and connected to the first ground electrode is provided, and dielectric layers 13p and 14p are interposed between the inner ground electrode 81p and the open end side of the resonant elements 21p and 22p. Furthermore,  
15 on the upper surface of the dielectric layer 12p, an inner layer ground electrode 83p positioned on an open end side of the resonant elements 23p, 24p, and 25p and connected to the first end ground electrode is provided, and the dielectric layers 13p and 14p are interposed between the inner layer ground electrode 83p and the open end side of the resonant elements 23p, 24p,  
20 and 25p. Furthermore, a through-hole 92p for connecting the first end ground electrode to the tip portion of the transmission line 70p is formed in the dielectric layer 12p.

On an upper surface of the dielectric layer 13p, a capacitive coupling electrode 50p is provided, one end 51p of which is overlapped with a part of  
25 the transmission line 70p with the dielectric layer 14p interposed therebetween and the other end 52p of which is overlapped with a part of the resonant element 23p with the dielectric layer 14p interposed therebetween. Furthermore, on the upper surface of the dielectric layer 13p, an input/output electrode 42p overlapped with a part of the resonant element 25p with the  
30 dielectric layer 14p interposed therebetween is provided. A through-hole 93p for connecting the first end ground electrode to the tip portion of the transmission line 70p is formed in the dielectric layer 13p.

The tip portion of the transmission line 70p is short-circuited with the first end ground electrode provided on the lower surface of the dielectric layer  
35 11p via the through-holes 94p, 93p, 92p, and 91p. The through-hole 94p is positioned so that an electric length of the transmission line 70p is a predetermined length of 90 degrees or less. Thus, the transmission line 70p

constitutes an inductor.

On an upper surface of the dielectric layer 15p, a capacitive electrode 60p is provided, one end 61p of which is overlapped with a part of the transmission line 70p with the dielectric layer 15p interposed therebetween, and the other end 62p of which is overlapped with a part of the resonant element 22p with the dielectric layer 15p interposed therebetween.

Furthermore, on the upper surface of the dielectric layer 15p, an input/output electrode 41p is provided, a part of which is overlapped with a part of the resonant element 21p with the dielectric layer 15p interposed therebetween.

A second end ground electrode 110p is provided on an upper surface of a dielectric layer 17p.

On an upper surface of a dielectric layer 16p, an inner layer ground electrode 82p positioned on the open end side of the resonant elements 21p and 22p and connected to the second end ground electrode 110p is provided, and the dielectric layers 15p and 16p are interposed between the inner layer ground electrode 82p and the open end side of the resonant elements 21p and 22p. Furthermore, on the upper surface of the dielectric layer 16p, an inner layer ground electrode 84p positioned on the open end side of the resonant elements 23p, 24p, and 25p and connected to the second end ground electrode 110p is provided, and the dielectric layers 15p and 16p are interposed between the inner layer ground electrode 84p and the open end side of the resonant elements 23p, 24p, and 25p.

The dielectric layers 11p, 12p, 13p, 14p, 15p, 16p, and 17p having the above-mentioned configuration are laminated to be integrated, followed by sintering, providing a duplexer composed of a laminate, in which dielectric layers and electrode layers are laminated alternately.

FIG. 25 shows an equivalent circuit of the duplexer having the above-mentioned configuration. As shown in FIGS. 24 and 25, a band-pass filter 500p is composed of the resonant elements 21p and 22p, and a band-pass filter 600p is composed of the resonant elements 23p, 24p, and 25p. A static capacitor 401p is formed between the capacitive electrode 60p and the transmission line 70p, and a static capacitor 402p is formed between the capacitive electrode 50p and the transmission line 70p. The inductor 403p is composed of the transmission line 70p. The inductor 403p is connected in parallel with the filters 500p and 600p, and the static capacitor 401p is connected in series between an antenna 700p and the filter 500p. The static capacitor 402p is connected in series between the antenna 700p and the filter

600p. The inductor 403p, and the static capacitors 401p and 402p constitute a branching circuit 400p.

FIG. 26 shows the transmission characteristics of a duplexer having the above-mentioned configuration. As shown in FIG. 26, it is understood that the branching circuit 400p shares one antennal on a transmitting side and a receiving side, and separates a transmitted signal and a received signal from each other.

As described above, the duplexer in the prior art includes a branching circuit provided between two filters in a triplet shape, in which resonant elements are provided integrally in a dielectric substrate. The branching circuit is configured by using static capacitors connected in series to each of the two filters and an inductor connected in parallel therewith.

However, in the above-mentioned configuration, the circuit configuration is complicated, so that a loss in the branching circuit is increased, and the layout space is necessarily increased. Furthermore, it is difficult to obtain a large L-value in the inductor connected in parallel with two filters, respectively, so that the degree of design freedom is lowered.

#### SUMMARY OF THE INVENTION

Therefore, with the foregoing in mind, it is an object of the present invention to provide a duplexer that can be realized with a very simple configuration, designed so as to substantially reduce a loss, and miniaturized easily, and a laminate-type high-frequency device and communication equipment using the duplexer. Furthermore, it is another object of the present invention to provide a duplexer that is improved so as to obtain a sufficient degree of design freedom, and a laminate-type high-frequency device and communication equipment using the duplexer.

In order to achieve the above-mentioned object, a first configuration of a duplexer of the present invention relates to a duplexer composed of a laminate in which dielectric layers and electrode layers are laminated alternately. The duplexer includes: a first filter for transmitting and a second filter for receiving, which are provided in the laminate and have different pass band frequencies; and a matching circuit composed of a coupling line, having one end that is short-circuited and the other end that is connected to an external terminal, provided between the first filter and the second filter. The first filter includes at least one first stripline resonator, having one end that is short-circuited. The second filter includes at least

one second stripline resonator, having one end that is short-circuited, and the first stripline resonator and the second stripline resonator are coupled to the coupling line by electromagnetic field coupling.

5 In the first configuration of the duplexer, a duplexer can be realized with a simple configuration in which the first stripline resonator and the second stripline resonator are coupled to the coupling line by electromagnetic field coupling, without using lumped-constant elements such as an inductor and a capacitor. Therefore, a loss can be reduced substantially.

10 In the first configuration of the duplexer of the present invention, it is preferable that at least one of the first stripline resonator and the second stripline resonator has a large line width on an open end side and a small line width on a short-circuited side. According to this preferable example, the coupling degree between the first and second stripline resonators and the coupling line can be changed arbitrarily. Therefore, the degree of design  
15 freedom is enhanced substantially.

In the first configuration of the duplexer of the present invention, it is preferable that the laminate includes a first dielectric layer, a second dielectric layer, a third dielectric layer, and a fourth dielectric layer laminated successively. It also is preferable that the electrode layers include: a first  
20 shield electrode placed on an upper surface of the first dielectric layer; an interstage coupling capacitive electrode constituting the first filter and an input/output coupling capacitive electrode constituting the second filter, placed between the first dielectric layer and the second dielectric layer; a first resonator electrode constituting the first filter, a second resonator electrode  
25 constituting the second filter, and a coupling line electrode constituting the matching circuit, placed between the second dielectric layer and the third dielectric layer; an input/output coupling capacitive electrode constituting the first filter and an interstage coupling capacitive electrode constituting the second filter, placed between the third dielectric layer and the fourth  
30 dielectric layer; a second shield electrode placed on a lower surface of the fourth dielectric layer; at least three terminal electrodes connected to the input/output coupling capacitive electrode constituting the first filter, the input/output coupling capacitive electrode constituting the second filter, and the coupling line electrode, respectively, provided on side surfaces of the first  
35 dielectric layer, the second dielectric layer, the third dielectric layer, and the fourth dielectric layer; and an end face electrode connecting the first shield electrode and the second shield electrode to each other.

According to the above preferable example, a duplexer can be realized with a very simple configuration, so that a substantial reduction in loss and miniaturization can be achieved.

Furthermore, in this case, it is preferable that at least one of the first  
5 dielectric layer, the second dielectric layer, the third dielectric layer, and the fourth dielectric layer has a dielectric constant different from that of the other dielectric layers. According to this preferable example, the capacitance of a capacitor can be adjusted.

Furthermore, in this case, it is preferable that the duplexer further  
10 includes an adjusting capacitive electrode provided so as to be opposed to the first shield electrode with the first dielectric layer interposed therebetween. An antenna can be used for both transmitting and receiving. According to the preferable example, the matching between transmitting and receiving can be optimized.

15 In the first configuration of the duplexer of the present invention, at least one of the first stripline resonator and the second stripline resonator is formed on a dielectric layer different from a dielectric layer on which the coupling line is formed. According to this preferable example, the degree of design freedom and versatility can be enhanced.

20 In the first configuration of the duplexer of the present invention, it is preferable that the coupling line is composed of at least two striplines having different line widths, connected to each other. According to this preferable example, the strength of electromagnetic field coupling can be changed arbitrarily.

25 In the first configuration of the duplexer of the present invention, it is preferable that the coupling line is composed of a plurality of striplines, and the plurality of striplines are provided on different dielectric layers.

According to this preferable example, an electric potential can be stabilized. Furthermore, in this case, it is preferable that at least one of the plurality of  
30 striplines has a line width different from that of the other striplines.

According to this preferable example, stronger electromagnetic field coupling can be obtained. Furthermore, in this case, it is preferable that the plurality of striplines are connected to each other by a via hole. According to this  
35 preferable example, because of the shield effect of the via hole, the first stripline resonator and the second stripline resonator can be separated from each other. Therefore, a frequency component can be prevented from being transmitted to a receiving side during transmitting, and a frequency

component can be prevented from being transmitted to a transmitting side during receiving.

In the first configuration of the duplexer of the present invention, it is preferable that the duplexer further includes a coupling capacitor provided so as to be overlapped with the coupling line and the stripline resonator with the dielectric layer interposed therebetween. According to this preferable example, the electric field coupling occurring due to a coupling capacitor is combined with electromagnetic field coupling occurring between the stripline resonator and the coupling line. In the coupling occurring between the stripline resonator and the coupling line, a magnetic field component is dominant. However, by providing the coupling capacitor, an electric field capacitance component can be increased.

In the first configuration of the duplexer of the present invention, it is preferable that the first filter and the second filter are provided so as to be opposed to each other with a shield electrode interposed therebetween. According to this preferable example, the first filter for transmitting and the second filter for receiving can be arranged in a vertical direction, so that the area occupied by the duplexer can be reduced.

Furthermore, in this case, it is preferable that the laminate includes a first dielectric layer, a second dielectric layer, a third dielectric layer, a fourth dielectric layer, a fifth dielectric layer, and a sixth dielectric layer laminated successively. It also is preferable that the electrode layers include: a first shield electrode placed on an upper surface of the first dielectric layer; an interstage coupling capacitive electrode and an input/output coupling capacitive electrode constituting the first filter, placed between the first dielectric layer and the second dielectric layer; a plurality of resonator electrodes constituting the first filter, placed between the second dielectric layer and the third dielectric layer; a third shield electrode and a coupling line electrode constituting the matching circuit, placed between the third dielectric layer and the fourth dielectric layer; a plurality of resonator electrodes and an input/output line electrode connected to the resonator electrodes constituting the second filter, placed between the fourth dielectric layer and the fifth dielectric layer; an interstage coupling capacitive electrode constituting the second filter, placed between the fifth dielectric layer and the sixth dielectric layer; a second shield electrode placed on a lower surface of the sixth dielectric layer; at least three terminal electrodes connected to the input/output coupling capacitive electrode, the input/output line electrode,

and the coupling line electrode, respectively, provided on side surfaces of the first dielectric layer, the second dielectric layer, the third dielectric layer, the fourth dielectric layer, the fifth dielectric layer, and the sixth dielectric layer; and an end face electrode connecting the first shield electrode, the second shield electrode, and the third shield electrode to each other.

According to the above preferable example, the first filter and the second filter can be arranged in a vertical direction, so that the area occupied by the duplexer can be reduced.

A second configuration of a duplexer of the present invention relates to a duplexer composed of a laminate in which dielectric layers and electrode layers are laminated alternately. The duplexer includes: a first shield electrode, a second shield electrode, a third shield electrode, and a fourth shield electrode arranged in the laminate in a lamination direction; a first filter configured in such a manner that a plurality of stripline resonators, each having one end that is short-circuited, are adjacent to each other in parallel, placed between the first shield electrode and the second shield electrode; a matching circuit composed of a coupling line, placed between the second shield electrode and the third shield electrode; and a second filter that is configured in such a manner that a plurality of stripline resonators, each having one end that is short-circuited, are adjacent to each other in parallel and that has a pass band frequency different from that of the first filter, placed between the third shield electrode and the fourth shield electrode. The second and third shield electrodes are provided with coupling windows, and the stripline resonators constituting the first and second filters and the coupling line are coupled to each other by electromagnetic field coupling via the coupling windows, respectively.

According to the second configuration of the duplexer, the versatility of the strength of electromagnetic field coupling can be obtained easily.

In the second configuration of the duplexer of the present invention, it is preferable that the laminate includes a first dielectric layer, a second dielectric layer, a third dielectric layer, a fourth dielectric layer, a fifth dielectric layer, a sixth dielectric layer, a seventh dielectric layer, and an eighth dielectric layer laminated successively. It also is preferable that the electrode layers include: a first shield electrode placed on an upper surface of the first dielectric layer; an interstage coupling capacitive electrode and an input/output coupling capacitive electrode constituting the first filter, placed between the first dielectric layer and the second dielectric layer; a plurality of



resonator electrodes constituting the first filter, placed between the second dielectric layer and the third dielectric layer; a third shield electrode partially provided with the coupling window, placed between the third dielectric layer and the fourth dielectric layer; a coupling line electrode constituting the matching circuit, placed between the fourth dielectric layer and the fifth dielectric layer; a fourth shield electrode partially provided with the coupling window, placed between the fifth dielectric layer and the sixth dielectric layer; a plurality of resonator electrodes and an input/output line electrode connected to the resonator electrodes constituting the second filter, placed between the sixth dielectric layer and the seventh dielectric layer; an interstage coupling capacitive electrode constituting the second filter, placed between the seventh dielectric layer and the eighth dielectric layer; a second shield electrode placed on a lower surface of the eighth dielectric layer; at least three terminal electrodes connected to the input/output coupling capacitive electrode, the input/output line electrode, and the coupling line electrode, respectively, provided on side surfaces of the first dielectric layer, the second dielectric layer, the third dielectric layer, the fourth dielectric layer, the fifth dielectric layer, the sixth dielectric layer, the seventh dielectric layer, and the eighth dielectric layer; and an end face electrode connecting the first shield electrode, the second shield electrode, the third shield electrode, and the fourth shield electrode to each other.

According to the above preferable example, a shield electrode is printed onto a dielectric layer, excluding a part thereof, whereby a coupling window is provided in the excluded part. Therefore, the strength of electromagnetic field coupling can be changed easily by such a simple method.

A third configuration of a duplexer of the present invention relates to a duplexer comprising a laminate in which dielectric layers and electrode layers are laminated alternately. The duplexer includes: a first filter for transmitting and a second filter for receiving, which are provided in the laminate and have different pass band frequencies; and a matching circuit composed of a coupling line, having one end that is opened and the other end that is connected to an external terminal, provided between the first filter and the second filter. The first filter includes at least one first stripline resonator, having one end that is short-circuited. The second filter includes at least one second stripline resonator, having one end that is short-circuited, and the first stripline resonator and the second stripline resonator are

coupled to the coupling line by electromagnetic field coupling.

According to the third configuration of the duplexer, even by using a coupling line, having one end that is opened and the other end that is connected to an external terminal, a duplexer can be operated.

5           In the third configuration of the duplexer of the present invention, it is preferable that a matching capacitive electrode is connected to an open end side of the coupling line with a dielectric layer interposed therebetween. In the case where one end of the coupling line is opened, floating capacitance is generated in the open end, which causes variation. However, according to  
10           this preferable example, such variation can be stabilized. Furthermore, by changing a capacitance value, the degree of design freedom can be obtained.

          In the third configuration of the duplexer of the present invention, it is preferable that at least one of the first stripline resonator and the second  
15           stripline resonator has a larger line width on an open end side and a smaller line width on a short-circuited end side.

          In the third configuration of the duplexer of the present invention, it is preferable that the laminate includes a first dielectric layer, a second dielectric layer, a third dielectric layer, and a fourth dielectric layer laminated successively. It also is preferable that the electrode layers include: a first  
20           shield electrode placed on an upper surface of the first dielectric layer; an interstage coupling capacitive electrode constituting the first filter and an input/output coupling capacitive electrode constituting the second filter, placed between the first dielectric layer and the second dielectric layer; a first resonator electrode constituting the first filter, a second resonator electrode  
25           constituting the second filter, and a coupling line electrode constituting the matching circuit, placed between the second dielectric layer and the third dielectric layer; an input/output coupling capacitive electrode constituting the first filter and an interstage coupling capacitor electrode constituting the second filter, placed between the third dielectric layer and the fourth  
30           dielectric layer; a second shield electrode placed on a lower surface of the fourth dielectric layer; at least three terminal electrodes connected to the input/output coupling capacitive electrode constituting the first filter, the input/output coupling capacitive electrode constituting the second filter, and the coupling line electrode, respectively, provided on side surfaces of the first  
35           dielectric layer, the second dielectric layer, the third dielectric layer, and the fourth dielectric layer; and an end face electrode connecting the first shield electrode and the second shield electrode to each other.

Furthermore, in this case, it is preferable that at least one of the first dielectric layer, the second dielectric layer, the third dielectric layer, and the fourth dielectric layer has a dielectric constant different from that of the other dielectric layers.

5           Furthermore, in this case, it is preferable that the duplexer further includes an adjusting capacitive electrode provided so as to be opposed to the first shield electrode with the first dielectric layer interposed therebetween.

          In the third configuration of the duplexer of the present invention, it is preferable that at least one of the first stripline resonator and the second  
10       stripline resonator is formed on a dielectric layer different from a dielectric layer on which the coupling line is formed.

          In the third configuration of the duplexer of the present invention, it is preferable that the coupling line is composed of at least two striplines having different line widths, connected to each other.

15           In the third configuration of the duplexer of the present invention, it is preferable that the coupling line is composed of a plurality of striplines, and the plurality of striplines are provided on different dielectric layers. Furthermore, in this case, it is preferable that at least one of the plurality of striplines has a line width different from that of the other striplines.  
20       Furthermore, in this case, it is preferable that the plurality of striplines are connected to each other by a via hole.

          In the third configuration of the duplexer of the present invention, it is preferable that the duplexer further includes a coupling capacitor provided so as to be overlapped with the coupling line and the stripline resonator with  
25       the dielectric layer interposed therebetween.

          In the third configuration of the duplexer of the present invention, it is preferable that the first filter and the second filter are provided so as to be opposed to each other with a shield electrode interposed therebetween.

          Furthermore, in this case, it is preferable that the laminate includes a  
30       first dielectric layer, a second dielectric layer, a third dielectric layer, a fourth dielectric layer, a fifth dielectric layer, and a sixth dielectric layer laminated successively. It also is preferable that the electrode layers include: a first shield electrode placed on an upper surface of the first dielectric layer; an interstage coupling capacitive electrode and an input/output coupling  
35       capacitive electrode constituting the first filter, placed between the first dielectric layer and the second dielectric layer; a plurality of resonator electrodes constituting the first filter, placed between the second dielectric

layer and the third dielectric layer; a third shield electrode and a coupling line electrode constituting the matching circuit, placed between the third dielectric layer and the fourth dielectric layer; a plurality of resonator electrodes and an input/output line electrode connected to the resonator electrodes constituting the second filter, placed between the fourth dielectric layer and the fifth dielectric layer; an interstage coupling capacitive electrode constituting the second filter, placed between the fifth dielectric layer and the sixth dielectric layer; a second shield electrode placed on a lower surface of the sixth dielectric layer; at least three terminal electrodes connected to the input/output coupling capacitive electrode, the input/output line electrode, and the coupling line electrode, respectively, provided on side surfaces of the first dielectric layer, the second dielectric layer, the third dielectric layer, the fourth dielectric layer, the fifth dielectric layer, and the sixth dielectric layer; and an end face electrode connecting the first shield electrode, the second shield electrode, and the third shield electrode to each other.

A fourth configuration of the duplexer of the present invention relates to a duplexer composed of a laminate in which dielectric layers and electrode layers are laminated alternately. The duplexer includes: a first filter for transmitting and a second filter for receiving, which are provided in the laminate and have different pass band frequencies; and a matching circuit composed of a coupling line, provided between the first filter and the second filter. At least one of the first and second filters is a filter composed of a stripline resonator, having one end that is short-circuited, and a transmission line, having band elimination characteristics, and the transmission line and the coupling line are coupled to each other by electromagnetic field coupling.

According to the fourth configuration of the duplexer, the filter eliminates only a particular high-frequency component. In the filter having band elimination characteristics, a loss can be reduced, compared with a filter having band pass characteristics. Therefore, a loss of a transmitting filter can be reduced.

In the fourth configuration of the duplexer of the present invention, it is preferable that the laminate includes a first dielectric layer, a second dielectric layer, a third dielectric layer, a fourth dielectric layer, and a fifth dielectric layer laminated successively. It also is preferable that the electrode layers include: a first shield electrode placed on an upper surface of the first dielectric layer; an interstage coupling capacitive electrode constituting the first filter, placed between the first dielectric layer and the

second dielectric layer; a plurality of resonator electrodes constituting the first filter and a coupling line electrode constituting the matching circuit, placed between the second dielectric layer and the third dielectric layer; an input/output coupling capacitive electrode constituting the first filter, a  
5 transmission line electrode constituting the second filter, having band elimination characteristics, and a coupling line electrode constituting a matching circuit, placed between the third dielectric layer and the fourth dielectric layer; a resonator electrode constituting the second filter, placed between the fourth dielectric layer and the fifth dielectric layer; a second  
10 shield electrode placed on a lower surface of the fifth dielectric layer; at least three terminal electrodes connected to the input/output coupling capacitive electrode, the transmission line electrode, and the coupling line electrode, respectively, provided on side surfaces of the first dielectric layer, the second dielectric layer, the third dielectric layer, the fourth dielectric layer, and the  
15 fifth dielectric layer; and an end face electrode connecting the first shield electrode and the second shield electrode to each other.

According to the above preferable example, because of the above-mentioned lamination configuration, a filter having band elimination characteristics can be formed easily.

20 In the fourth configuration of the duplexer of the present invention, it is preferable that the laminate includes a first dielectric layer, a second dielectric layer, a third dielectric layer, a fourth dielectric layer, and a fifth dielectric layer laminated successively. It also is preferable that the electrode layers include: a first shield electrode placed on an upper surface of  
25 the first dielectric layer; an interstage coupling capacitive electrode constituting the first filter, placed between the first dielectric layer and the second dielectric layer; a plurality of resonator electrodes constituting the first filter and a coupling line electrode constituting the matching circuit, placed between the second dielectric layer and the third dielectric layer; an  
30 input/output coupling capacitive electrode constituting the first filter and a transmission line electrode constituting the second filter, having band elimination characteristics, placed between the third dielectric layer and the fourth dielectric layer; a resonator electrode constituting the second filter, placed between the fourth dielectric layer and the fifth dielectric layer; a  
35 second shield electrode placed on a lower surface of the fifth dielectric layer; at least three terminal electrodes connected to the input/output coupling capacitive electrode, the transmission line electrode, and the coupling line

electrode, respectively, provided on side surfaces of the first dielectric layer, the second dielectric layer, the third dielectric layer, the fourth dielectric layer, and the fifth dielectric layer; and an end face electrode connecting the first shield electrode and the second shield electrode to each other. It also is preferable that a part of the transmission line electrode is overlapped with the coupling line electrode with the third dielectric layer interposed therebetween in a projection in a lamination direction, and in the projection in the lamination direction, a width of the part of the transmission line electrode is the same as or different from that of the coupling line electrode.

According to the above preferable example, since the coupling line electrode and the transmission line electrode are placed in a vertical direction, electromagnetic field coupling becomes stronger. Furthermore, the width of a part of the transmission line electrode is set to be different from that of the coupling line electrode, whereby a margin can be provided with respect to a shift in overlapping during lamination.

A laminate-type high-frequency device of the present invention includes: a duplexer composed of a laminate in which dielectric layers and electrode layers are laminated alternately; and a semiconductor chip and/or a surface acoustic wave device mounted on an upper surface of the laminate.

The duplexer of the present invention is used as the duplexer.

According to the configuration of the laminate-type high-frequency device, since a duplexer can be realized with a very simple configuration, a laminate-type high-frequency device, in which a loss can be reduced substantially and which is provided with a semiconductor chip and/or a surface acoustic wave device, can be obtained.

Communication equipment of the present invention includes: an antenna; and a duplexer for transmitting a frequency component output from a transmitting circuit to the antenna and transmitting a frequency component received from the antenna to a receiving circuit, composed of a laminate in which dielectric layers and electrode layers are laminated alternately. The duplexer of the present invention is used as the duplexer.

According to the configuration of the communication equipment, a duplexer can be realized with a very simple configuration. Therefore, communication equipment in which a loss can be reduced substantially can be obtained.

In the configuration of the communication equipment of the present invention, it is preferable that the communication equipment further includes

at least one selected from a semiconductor chip and a surface acoustic wave device mounted on an upper surface of the laminate. According to this preferable example, communication equipment can be obtained that includes a laminate-type high-frequency device in which a loss can be reduced substantially and has a semiconductor chip and/or a surface acoustic wave device.

According to the present invention, it is possible to obtain a duplexer that can be realized with a very simple configuration, designed so as to substantially reduce a loss, and miniaturized easily, and a laminate-type high-frequency device and communication equipment using the duplexer. Furthermore, according to the present invention, it is possible to obtain a duplexer that is improved so as to obtain a sufficient degree of design freedom, and a laminate-type high-frequency device and communication equipment using the duplexer.

These and other advantages of the present invention will become apparent to those skilled in the art upon reading and understanding the following detailed description with reference to the accompanying figures.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view showing a duplexer according to an embodiment of the present invention.

FIG. 2 is an exploded perspective view showing a duplexer according to Embodiment 1 of the present invention.

FIG. 3 is an equivalent circuit diagram of the duplexer according to Embodiment 1 of the present invention.

FIG 4 shows transmission characteristics of the duplexer according to Embodiment 1 of the present invention.

FIG. 5 is an exploded perspective view showing another example of a duplexer according to the embodiment of the present invention.

FIG. 6 is an exploded perspective view showing a duplexer according to Embodiment 2 of the present invention.

FIG. 7 is an exploded perspective view showing a duplexer according to Embodiment 3 of the present invention.

FIG. 8 is an exploded perspective view showing a duplexer according to Embodiment 4 of the present invention.

FIG. 9 is an exploded perspective view showing a duplexer according to Embodiment 5 of the present invention.

FIG. 10 is an exploded perspective view showing a duplexer according to Embodiment 6 of the present invention.

FIG. 11 is an equivalent circuit diagram of the duplexer according to Embodiment 6 of the present invention.

5        FIG. 12 is an exploded perspective view showing a duplexer according to Embodiment 7 of the present invention.

FIG. 13 is an exploded perspective view showing a duplexer according to Embodiment 8 of the present invention.

10       FIG. 14 is an exploded perspective view showing another example of the duplexer according to Embodiment 8 of the present invention.

FIG. 15 is an equivalent circuit diagram of the duplexer according to Embodiment 8 of the present invention shown in FIG. 14.

FIG. 16 is an exploded perspective view showing a duplexer according to Embodiment 9 of the present invention.

15       FIG. 17 is an equivalent circuit diagram of the duplexer according to Embodiment 9 of the present invention.

FIG. 18 shows transmission characteristics of the duplexer according to Embodiment 9 of the present invention.

20       FIG. 19 is an exploded perspective view showing another example of the duplexer according to Embodiment 9 of the present invention.

FIG. 20 is an equivalent circuit diagram of the duplexer according to Embodiment 9 of the present invention shown in FIG. 19.

FIG. 21 is an exploded perspective view showing a duplexer according to Embodiment 10 of the present invention.

25       FIG. 22 is a schematic perspective view showing a laminate-type high-frequency device according to Embodiment 11 of the present invention.

FIG. 23 is a schematic view showing communication equipment according to Embodiment 12 of the present invention.

30       FIG. 24 is an exploded perspective view showing a duplexer in the prior art.

FIG. 25 is an equivalent circuit diagram of the duplexer in the prior art.

FIG. 26 illustrates the function of a branching circuit.

## 35       DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the present invention will be described in detail by way of illustrative embodiments with reference to the drawings.



FIG. 1 is a schematic view showing a duplexer according to an embodiment of the present invention. As shown in FIG. 1, in the duplexer according to the present embodiment, resonators and a coupling line are provided integrally in a dielectric substrate. Two filters for transmitting and receiving are configured in a triplet shape. A matching circuit composed of a coupling line is provided between the transmitting filter and the receiving filter. The coupling line is connected to an antenna terminal (ANT). The transmitting filter is connected to a terminal (TX) of a transmitting circuit, and the receiving filter is connected to a terminal (RX) of a receiving circuit. The coupling line is coupled directly to the resonators of the transmitting filter and the receiving filter, closest to the coupling line, by electromagnetic field coupling (M). More specifically, the coupling line is coupled to the resonators of the transmitting and receiving filters in terms of high frequencies by the combination of magnetic coupling and electric field coupling, whereby desired duplexer characteristics are realized. Thus, according to the present embodiment, a duplexer can be realized with a very simple configuration, so that a loss can be reduced substantially.

#### Embodiment 1

FIG. 2 is an exploded perspective view showing a duplexer according to Embodiment 1 of the present invention.

As shown in FIG. 2, the duplexer according to the present embodiment is composed of a laminate in which dielectric layers and electrode layers are laminated alternately. In the laminate, a first filter for transmitting and a second filter for receiving, having different pass band frequencies, are provided. Furthermore, a matching circuit composed of a coupling line 9, having one end that is short-circuited and the other end that is connected to an external terminal, is provided between the first filter and the second filter.

The first filter includes two first stripline resonators 3a and 3b, each having one end that is short-circuited. The second filter includes two second stripline resonators 4a and 4b, each having one end that is short-circuited. The coupling line 9 is coupled to the first stripline resonator 3b close to the coupling line 9 by electromagnetic field coupling. The coupling line 9 is coupled to the second stripline resonator 4a close to the coupling line 9 by electromagnetic field coupling.

In the present embodiment, the first stripline resonators 3a, 3b and

the second stripline resonators 4a, 4b have a large line width (wide portion) on the open end side and a small line width (narrow portion) on the short-circuited end side. Thus, by adopting a configuration in which the line width of the stripline resonators is varied between the open end side and the short-circuited end side, the coupling degree between the first and second stripline resonators 3b, 4a and the coupling line 9 can be varied arbitrarily, whereby the degree of design freedom is enhanced greatly.

Next, an actual configuration of the duplexer according to the present embodiment will be described in detail.

The laminate includes a first dielectric layer 1a, a second dielectric layer 1b, a third dielectric layer 1c, and a fourth dielectric layer 1d laminated successively. Herein, each dielectric layer may be made of glass ceramic.

The electrode layer has the following configuration. A first shield electrode 2a is placed on an upper surface of the first dielectric layer 1a: An interstage coupling capacitive electrode 5 constituting the first filter and an input/output coupling capacitive electrode 8 constituting the second filter are placed between the first dielectric layer 1a and the second dielectric layer 1b. First resonator electrodes (first stripline resonators) 3a, 3b constituting the first filter, second resonator electrodes (second stripline resonators) 4a, 4b constituting the second filter, and the coupling line electrode (coupling line) 9 are placed between the second dielectric layer 1b and the third dielectric layer 1c. The input/output coupling capacitive electrode 7 constituting the first filter and the interstage coupling capacitive electrode 6 constituting the second filter are placed between the third dielectric layer 1c and the fourth dielectric layer 1d. A second shield electrode 2b is placed on a lower surface of the fourth dielectric layer 1d. At least three terminal electrodes (external terminals) 10a, 10b (terminal electrodes (external terminals) corresponding to the input/output coupling capacitive electrode 7 are not shown) connected to the input/output coupling capacitive electrodes 7, 8 and the coupling line electrode 9 are provided on side surfaces of the first dielectric layer 1a, the second dielectric layer 1b, the third dielectric layer 1c, and the fourth dielectric layer 1d. The first shield electrode 2a and the second shield electrode 2b are connected by end face electrodes 11a and 11b. Herein, each electrode may be made of a conductive material mainly containing silver.

According to the configuration of the present embodiment, a duplexer can be realized with a very simple configuration in which the first resonator electrode 3b and the second resonator electrode 4a are coupled to the coupling

line electrode 9 by electromagnetic field coupling without using lumped-constant elements such as an inductor and a capacitor. Therefore, a loss can be reduced substantially.

5 In the duplexer according to the present embodiment, it is desirable that at least one of the first dielectric layer 1a, the second dielectric layer 1b, the third dielectric layer 1c, and the fourth dielectric layer 1d has a dielectric constant different from those of the other dielectric layers. The dielectric constant can be adjusted by varying the composition of glass ceramic. Thus, by setting the dielectric constant of at least one of a plurality of dielectric  
10 layers to be different from those of the other dielectric layers, the capacitance of a capacitor can be adjusted.

FIG. 3 shows an equivalent circuit of the duplexer having the above-mentioned configuration. As shown in FIG. 3, the duplexer according to the present embodiment includes interstage coupling capacitors 23, 24,  
15 input/output coupling capacitors 25, 26, a coupling line 27, and resonators 21a, 21b, 22a, and 22b. Herein, the coupling line 27 is coupled to a wide portion of the resonator 21b close to the coupling line 27 by electromagnetic field coupling M1. The coupling line 27 is coupled to a narrow portion of the resonator 21b by electromagnetic field coupling M2. The coupling line 27 is  
20 coupled to a wide portion of the resonator 22a close to the coupling line 27 by electromagnetic field coupling M3. Furthermore, the coupling line 27 is coupled to a narrow portion of the resonator 22a by electromagnetic field coupling M4.

FIG. 4 shows the transmission characteristics of a duplexer having  
25 the above-mentioned configuration. In FIG. 4, TX→ANT represents the characteristics of the transmitting filter, and ANT→RX represents the characteristics of the receiving filter. As shown in FIG. 4, it is understood that the duplexer according to the present embodiment transmits only a required frequency component and does not transmit an unnecessary  
30 frequency component during transmitting. Furthermore, it is understood that the duplexer according to the present embodiment transmits only a required frequency component and does not transmit an unnecessary frequency component during receiving. Thus, if the duplexer according to the present embodiment is used, a frequency component can be prevented  
35 from being transmitted to a receiving side during transmitting, and a frequency component can be prevented from being transmitted to the transmitting side during receiving.

As a variation of the present embodiment, it also is desirable that a coupling capacitor 18 is provided so as to be overlapped with the coupling line 9 and the stripline resonators 3b, 4a via the dielectric layer 1b. According to this configuration, the electric field coupling occurring due to the coupling  
5 capacitor 18 is combined with the electromagnetic field coupling occurring between the stripline resonators 3b, 4a and the coupling line 9. In the electromagnetic field coupling occurring between the stripline resonators 3b, 4a and the coupling line 9, a magnetic field component is dominant; however, an electric field capacitive component can be increased by providing the  
10 coupling capacitor 18.

In the present embodiment, the first filter is configured so as to include the first stripline resonators 3a, 3b, each having one end that is short-circuited, and the second filter is configured so as to include the second  
15 stripline resonators 4a, 4b, each having one end that is short-circuited. However, the present invention is not limited thereto. The first filter may include at least one first stripline resonator, having one end that is short-circuited, and the second filter may include at least one second stripline resonator, having one end that is short-circuited.

Furthermore, in the present embodiment, the first stripline  
20 resonators 3a, 3b and the second stripline resonators 4a, 4b are configured so as to have a large line width on an open end side and a small line width on a short-circuited side. However, the present invention is not limited thereto. At least one of the first and second stripline resonators may have a large line width on the open end side and a small line width on the short-circuited end  
25 side.

## Embodiment 2

FIG. 6 is an exploded perspective view showing a duplexer according to Embodiment 2 of the present invention. The duplexer according to the  
30 present embodiment is the same as that according to Embodiment 1 except for the points described below. Therefore, like components are denoted with like numerals, and their description will be omitted here.

As shown in FIG. 6, in the duplexer according to the present embodiment, the first stripline resonators 3a, 3b and the second stripline  
35 resonators 4a, 4b are formed on dielectric layers 1c, 1e, different from the dielectric layer 1d on which the coupling line 9 is formed. Thus, by forming the first stripline resonators 3a, 3b and the second stripline resonators 4a, 4b

on the dielectric layers 1c, 1e different from the dielectric layer 1d on which the coupling line 9 is formed, the degree of design freedom and versatility can be provided.

Furthermore, the coupling line 9 is composed of two striplines (wide portion and narrow portion) having different line widths and connected to each other. Thus, by configuring the coupling line 9 with two striplines having different line widths, the strength of electromagnetic field coupling can be varied arbitrarily.

In the present embodiment, the first stripline resonators 3a, 3b and the second stripline resonators 4a, 4b are formed on the dielectric layers 1c, 1e different from the dielectric layer 1d on which the coupling line 9 is formed. However, the present invention is not limited thereto. At least one of the first stripline resonator and the second stripline resonator may be formed on a dielectric layer different from a dielectric layer on which a coupling line is formed.

Furthermore, in the present embodiment, although the coupling line 9 is composed of two striplines having different line widths connected to each other, the present invention is not limited thereto. The coupling line may be composed of three or more striplines having different line widths connected to each other.

### Embodiment 3

FIG. 7 is an exploded perspective view showing a duplexer according to Embodiment 3 of the present invention. The duplexer according to the present embodiment is the same as that according to Embodiment 2 except for the points described below. Therefore, like components are denoted with like numerals, and their description will be omitted here.

As shown in FIG. 7, in the duplexer according to the present embodiment, the coupling line is composed of three striplines 9a, 9b, and 9c, and the three striplines 9a, 9b, and 9c are provided on different dielectric layers 1c, 1d, and 1e, respectively. In the case where there is only one stripline, an electric potential is fluctuated. However, by using three striplines, the electric potential can be stabilized.

It is desirable that at least one of the three striplines 9a, 9b, and 9c has a line width different from those of the others. In the present embodiment, all the striplines 9a, 9b, and 9c are configured so as to have different line widths. The electromagnetic field coupling is varied depending

upon the line width of a connecting line. Therefore, by varying the line width of the coupling line, stronger electromagnetic field coupling can be obtained.

5 In the present embodiment, although the coupling line is composed of three striplines 9a, 9b, and 9c, the present invention is not limited thereto. The coupling line may be composed of a plurality of striplines.

#### Embodiment 4

10 FIG. 8 is an exploded perspective view showing a duplexer according to Embodiment 4 of the present invention. The duplexer according to the present embodiment is the same as that according to Embodiment 3 except for the points described below. Therefore, like components are denoted with like numerals, and their description will be omitted here.

15 As shown in FIG. 8, in the duplexer according to the present embodiment, three striplines 9a, 9b, and 9c are connected to each other through a via hole 12.

20 According to the configuration of the present embodiment, because of the shield effect of the via hole 12, the first stripline resonators 3a, 3b can be separated from the second stripline resonators 4a, 4b. Therefore, a frequency component can be prevented from being transmitted to a receiving side during transmitting, and a frequency component can be prevented from being transmitted to a transmitting side during receiving.

#### Embodiment 5

25 FIG. 9 is an exploded perspective view showing a duplexer according to Embodiment 5 of the present invention.

30 As shown in FIG. 9, the duplexer according to the present embodiment is composed of a laminate in which dielectric layers and electrode layers are laminated alternately. In the laminate, a first filter for transmitting and a second filter for receiving, having different pass band frequencies, are provided so as to be opposed to each other with a third shield electrode 32c interposed therebetween. Furthermore, a matching circuit composed of a coupling line 39, having one end that is short-circuited and the other end that is connected to an external terminal, is provided between the  
35 first filter and the second filter.

The first filter includes two first stripline resonators 33a and 33b, each having one end that is short-circuited. Furthermore, the second filter

includes two second stripline resonators 34a and 34b, each having one end that is short-circuited. The coupling line 39 is connected to the first stripline resonator 33b by electromagnetic field coupling. The coupling line 39 is coupled to the second stripline resonator 34b by electromagnetic field coupling.

Next, an actual configuration of the duplexer according to the present embodiment will be described in detail.

The laminate includes a first dielectric layer 31a, a second dielectric layer 31b, a third dielectric layer 31c, a fourth dielectric layer 31d, a fifth dielectric layer 31e, and a sixth dielectric layer 31f laminated successively.

The electrode layer has the following configuration. A first shield electrode 32a is placed on an upper surface of the first dielectric layer 31a. An interstage coupling capacitive electrode 35 and an input/output coupling capacitive electrode 37, constituting the first filter, are placed between the first dielectric layer 31a and the second dielectric layer 31b. The first resonator electrodes (first stripline resonators) 33a and 33b constituting the first filter are placed between the second dielectric layer 31b and the third dielectric layer 31c. The third shield electrode 32c and the coupling line electrode 39 constituting the matching circuit are placed between the third dielectric layer 31c and the fourth dielectric layer 31d. The second resonator electrodes (second stripline resonators) 34a, 34b and the input/output line electrode 38 connected to the resonator electrode 34a, constituting the second filter, are placed between the fourth dielectric layer 31d and the fifth dielectric layer 31e. The interstage coupling capacitive electrode 36 constituting the second filter is placed between the fifth dielectric layer 31e and the sixth dielectric layer 31f. The second shield electrode 32b is placed on a lower surface of the sixth dielectric layer 31f. At least three terminal electrodes 40a, 40b (terminal electrodes corresponding to the input/output coupling capacitive electrode 37 and the input/output line electrode 38 are not shown) connected to the input/output coupling capacitive electrode 37, the input/output line electrode 38, and the coupling line electrode 39, respectively, are provided on side surfaces of the first dielectric layer 31a, the second dielectric layer 31b, the third dielectric layer 31c, the fourth dielectric layer 31d, the fifth dielectric layer 31e, and the sixth dielectric layer 31f. The first shield electrode 32a, the second shield electrode 32b, and the third shield electrode 32c are connected by an end face electrode 41.

According to the configuration of the present embodiment, the first

filter for transmitting and the second filter for receiving can be arranged in a vertical direction (lamination direction), so that the area occupied by the duplexer can be decreased. The duplexer of the present embodiment has a laminated configuration, which enables vertical arrangement.

5 In the present embodiment, the first filter is configured so as to include two first stripline resonators 33a and 33b, each having one end that is short-circuited, and the second filter is configured so as to include two second stripline resonators 34a and 34b, each having one end that is short-circuited. However, the present invention is not limited thereto. The first filter may  
10 include three or more first stripline resonators, each having one end that is short-circuited, and the second filter may include three or more second stripline resonators, each having one end that is short-circuited.

#### Embodiment 6

15 FIG. 10 is an exploded perspective view showing a duplexer according to Embodiment 6 of the present invention.

As shown in FIG. 10, the duplexer according to the present embodiment is composed of a laminate in which dielectric layers and electrode layers are laminated alternately. In the laminate, a first shield  
20 electrode 32a, a third shield electrode 32c, a fourth shield electrode 32d, and a second shield electrode 32b are arranged in a lamination direction. A first filter is provided between the first shield electrode 32a and the third shield electrode 32c. In the first filter, two first stripline resonators 33a and 33b, each having one end that is short-circuited, are arranged in parallel so as to  
25 be close to each other. A matching circuit composed of a coupling line 39, having one end that is short-circuited and the other end that is connected to an external terminal, is provided between the third shield electrode 32c and the fourth shield electrode 32d. A second filter is provided between the fourth shield electrode 32d and the second shield electrode 32b. In the  
30 second filter, two second stripline resonators 34a and 34b, each having one end that is short-circuited, are arranged in parallel so as to be close to each other. The second filter has a different pass band frequency from that of the first filter. Coupling windows 42a and 42b are provided in the third shield electrode 32c and the fourth shield electrode 32d, respectively. The first  
35 stripline resonator 33b constituting the first filter and the coupling line 39 are coupled to each other by electromagnetic field coupling via the coupling window 42a. Furthermore, the second stripline resonator 34b constituting



the second filter and the coupling line 39 are coupled to each other by electromagnetic field coupling via the coupling window 42b.

In the coupling windows 42a and 42b, shield electrodes are not printed. By providing the coupling windows 42a and 42b, the versatility of the strength of electromagnetic field coupling can be obtained easily.

Next, an actual configuration of the duplexer according to the present embodiment will be described in detail.

The laminate includes a first dielectric layer 31a, a second dielectric layer 31b, a third dielectric layer 31c, a fourth dielectric layer 31g, a fifth dielectric layer 31h, a sixth dielectric layer 31d, a seventh dielectric layer 31e, and an eighth dielectric layer 31f laminated successively.

The electrode layer has the following configuration. The first shield electrode 32a is placed on an upper surface of the first dielectric layer 31a. An interstage coupling capacitive electrode 35 and an input/output coupling capacitive electrode 37, constituting the first filter, are placed between the first dielectric layer 31a and the second dielectric layer 31b. The first resonator electrodes (first stripline resonators) 33a and 33b constituting the first filter are placed between the second dielectric layer 31b and the third dielectric layer 31c. The third shield electrode 32c partially provided with the coupling window 42a is placed between the third dielectric layer 31c and the fourth dielectric layer 31g. The coupling line electrode 39 constituting the matching circuit, having one end that is short-circuited and the other end that is connected to an external terminal, is placed between the fourth dielectric layer 31g and the fifth dielectric layer 31h. The fourth shield electrode 32d partially provided with the coupling window 42b is placed between the fifth dielectric layer 31h and the sixth dielectric layer 31d. The second resonator electrodes (second stripline resonators) 34a, 34b and the input/output line electrode 38 connected to the second resonator electrode 34a, constituting the second filter, are placed between the sixth dielectric layer 31d and the seventh dielectric layer 31e. Furthermore, the interstage coupling capacitive electrode 36 constituting the second filter is placed between the seventh dielectric layer 31e and the eighth dielectric layer 31f. The second shield electrode 32b is placed on a lower surface of the eighth dielectric layer 31f. At least three terminal electrodes 40a, 40b (terminal electrodes corresponding to the input/output coupling capacitive electrode 37 and the input/output line electrode 38 are not shown) connected to the input/output coupling capacitive electrode 37, the input/output line electrode

38, and the coupling line electrode 39, respectively, are provided on side surfaces of the first dielectric layer 31a, the second dielectric layer 31b, the third dielectric layer 31c, the fourth dielectric layer 31g, the fifth dielectric layer 31h, the sixth dielectric layer 31d, the seventh dielectric layer 31e, and the eighth dielectric layer 31f. The first shield electrode 32a, the third shield electrode 32c, the fourth shield electrode 32d, and the second shield electrode 32b are connected by an end face electrode 41.

According to the configuration of the present embodiment, the shield electrodes are printed onto the dielectric layers, excluding a part thereof, whereby coupling windows 42a and 42b are provided. Thus, the strength of electromagnetic field coupling can be changed easily by such a simple method.

FIG. 11 shows an equivalent circuit of a duplexer having the above-mentioned configuration. The equivalent circuit of the duplexer in the present embodiment is the same as that shown in FIG. 3 except for the following points. Therefore, like components are denoted with like reference numerals, and their description will be omitted here.

The equivalent circuit of the duplexer in the present embodiment is different from that shown in FIG. 3 in that a coupling capacitor 28a is provided so as to be overlapped with the coupling line 27 and the stripline resonator 21b with a dielectric layer interposed therebetween, and a coupling capacitor 28b is provided so as to be overlapped with the coupling line 27 and the stripline resonator 22a with a dielectric layer interposed therebetween. Because of this, the electric field coupling occurring due to the coupling capacitors 28a and 28b is combined with the electromagnetic field coupling occurring between the stripline resonators 22a, 21b and the coupling line 27. In the electromagnetic field coupling occurring between the stripline resonators 22a, 21b and the coupling line 27, a magnetic field component is dominant; however, an electric field capacitive component can be increased by providing the coupling capacitors 28a and 28b.

#### Embodiment 7

FIG. 12 is an exploded perspective view showing a duplexer according to Embodiment 7 of the present invention. The duplexer according to the present embodiment is the same as that according to Embodiment 1 shown in FIG. 2 except for the points described below. Therefore, like components are denoted with like reference numerals, and their description will be omitted

here.

As shown in FIG. 12, in the duplexer according to the present embodiment, an adjusting capacitive electrode 13 is provided so as to be opposed to the first shield electrode 2a with the first dielectric layer 1a interposed therebetween. An antenna is used for both transmitting and receiving. The matching between transmitting and receiving can be optimized by providing the adjusting capacitive electrode 13.

#### Embodiment 8

FIG. 13 is an exploded perspective view showing a duplexer according to Embodiment 8 of the present invention. The duplexer according to the present embodiment is the same as that according to Embodiment 1 shown in FIG. 2 except for the points described below. Therefore, like components are denoted with like reference numerals, and their description will be omitted here.

As shown in FIG. 13, in the duplexer according to the present embodiment, a matching circuit composed of a coupling line 9, having one end that is opened and the other end that is connected to an external terminal, is provided between the first filter and the second filter. Thus, by using the coupling line 9, having one end that is opened and the other end that is connected to an external terminal, a duplexer can be operated.

As a variation of the present embodiment, as shown in FIG. 14, it is desirable that a matching capacitive electrode 14 is provided on an open end side of the coupling line 9 with the third dielectric layer 1c interposed therebetween. In the case where one end of the coupling line 9 is opened, floating capacitance is generated on the open end, which causes the variation in capacitance. However, by providing the matching capacitive electrode 14 on the open end side of the coupling line 9 with the third dielectric layer 1c interposed therebetween, a capacitance value can be stabilized.

Furthermore, by changing the capacitance value of matching capacitance, the degree of design freedom can be obtained.

FIG. 15 shows an equivalent circuit of the duplexer shown in FIG. 14. The equivalent circuit shown in FIG. 15 is the same as that shown in FIG. 3 except for the points described below. Therefore, like components are denoted with like reference numerals, and their description will be omitted here.

The equivalent circuit shown in FIG. 15 is different from that shown

in FIG. 3, in that a matching capacitor 29 is provided on the open end side of a coupling line 27.

Furthermore, as a variation of the present embodiment, it is desirable to use the configurations described in Embodiments 2 to 5 or 7.

5

#### Embodiment 9

FIG. 16 is an exploded perspective view showing a duplexer according to Embodiment 9 of the present invention.

As shown in FIG. 16, the duplexer according to the present  
10 embodiment is composed of a laminate in which dielectric layers and electrode layers are laminated alternately. In the laminate, a first filter for transmitting and a second filter for receiving having different pass band frequencies are provided. At least one of the first and second filters (second filter in the present embodiment) is composed of second stripline resonators  
15 54a, 54b, each having one end that is short-circuited and a transmission line 57, having band elimination characteristics. A matching circuit composed of coupling lines 58a and 58b, each having one end that is short-circuited and the other end that is connected to an external terminal, is provided between the first filter and the second filter. The transmission line 57 is coupled to  
20 the coupling line 58b by electromagnetic field coupling.

Next, an actual configuration of the duplexer according to the present embodiment will be described in detail.

The laminate includes a first dielectric layer 51a, a second dielectric layer 51b, a third dielectric layer 51c, a fourth dielectric layer 51d, and a fifth  
25 dielectric layer 51e laminated successively.

The electrode layer has the following configuration. A first shield electrode 52a is placed on an upper surface of the first dielectric layer 51a. An interstage coupling capacitive electrode 55 constituting the first filter is placed between the first dielectric layer 51a and the second dielectric layer  
30 51b. First resonator electrodes (first stripline resonators) 53a, 53b constituting the first filter, and the coupling line electrode 58a constituting a matching circuit are placed between the second dielectric layer 51b and the third dielectric layer 51c. An input/output coupling capacitive electrode 56 constituting the first filter, the transmission line electrode 57 constituting the  
35 second filter having band elimination characteristics, and the coupling line electrode 58b constituting a matching circuit are placed between the third dielectric layer 51c and the fourth dielectric layer 51d. The second resonator

electrodes (second stripline resonators) 54a and 54b constituting the second filter are placed between the fourth dielectric layer 51d and the fifth dielectric layer 51e. A second shield electrode 52b is placed on a lower surface of the fifth dielectric layer 51e. At least three terminal electrodes 59a, 59b  
5 (terminal electrodes corresponding to the input/output coupling capacitive electrode 56 are not shown) connected to the input/output coupling capacitive electrode 56, the transmission line electrode 57, and the coupling line electrodes 58a, 58b are provided on side surfaces of the first dielectric layer 51a, the second dielectric layer 51b, the third dielectric layer 51c, the fourth  
10 dielectric layer 51d, and the fifth dielectric layer 51e. The first shield electrode 52a and the second shield electrode 52b are connected by end face electrodes 60a and 60b.

According to the configuration of the present embodiment, because of the above-mentioned laminated configuration, a filter having band  
15 elimination characteristics can be formed easily.

FIG. 17 shows an equivalent circuit of a duplexer having the above-mentioned configuration. As shown in FIG. 17, the duplexer of the present embodiment includes an interstage coupling capacitor 63, an input/output coupling capacitor 64, and a transmission line 65. The first  
20 filter includes resonators 61a and 61b. A resonator 62a is connected to the transmission line 65 via a notch capacitor 66a, and a resonator 62b is connected to the transmission line 65 via a notch capacitor 66b.

FIG. 18 shows the transmission characteristics of a duplexer having the above-mentioned configuration. In the present embodiment, the second  
25 filter for transmitting is composed of the second stripline resonators 54a, 54b, each having one end that is short-circuited, and the transmission line 57, having band elimination characteristics. Therefore, the second filter eliminates only a particular high-frequency component. The loss can be reduced in the filter having band elimination characteristics, compared with  
30 the filter having band pass characteristics. Therefore, the loss of a transmitting filter can be reduced.

As a variation of the present embodiment, even when a matching circuit composed of coupling lines 58a and 58b, each having one end that is opened and the other end that is connected to an external terminal, is  
35 provided between the first and second filters as shown in FIG. 19, the same effects can be obtained.

FIG. 20 shows an equivalent circuit of the duplexer shown in FIG. 19.

In the present embodiment, the first filter is configured so as to include the first stripline resonators 53a, 53b, each having one end that is short-circuited, and the second filter is configured so as to include the second stripline resonators 54a, 54b, each having one end that is short-circuited.

- 5 However, the present invention is not limited thereto. The first filter may include three or more first stripline resonators, each having one end that is short-circuited, and the second filter may include three or more second stripline resonators, each having one end that is short-circuited.

#### 10 Embodiment 10

FIG. 21 is an exploded perspective view showing a duplexer according to Embodiment 10 of the present invention. The duplexer according to the present embodiment is a variation of the duplexer according to Embodiment 9.

- 15 As shown in FIG. 21, a laminate includes a first dielectric layer 51a, a second dielectric layer 51b, a third dielectric layer 51c, a fourth dielectric layer 51d, and a fifth dielectric layer 51e laminated successively.

- The electrode layer has the following configuration. A first shield electrode 52a is placed on an upper surface of the first dielectric layer 51a.
- 20 An interstage coupling capacitive electrode 55 constituting the first filter is placed between the first dielectric layer 51a and the second dielectric layer 51b. First resonator electrodes (first stripline resonators) 53a and 53b constituting the first filter, and a coupling line electrode 58c constituting a matching circuit are placed between the second dielectric layer 51b and the
- 25 third dielectric layer 51c. An input/output coupling capacitive electrode 56 constituting the first filter and a transmission line electrode 57 constituting the second filter having band elimination characteristics are placed between the third dielectric layer 51c and the fourth dielectric layer 51d. Second resonator electrodes (second stripline resonators) 54a and 54b constituting
- 30 the second filter are placed between the fourth dielectric layer 51d and the fifth dielectric layer 51e. A second shield electrode 52b is placed on a lower surface of the fifth dielectric layer 51e. At least three terminal electrodes 59a, 59b (terminal electrodes corresponding to the input/output coupling capacitive electrode 56 are not shown) connected to the input/output coupling
- 35 capacitive electrode 56, the transmission line electrode 57, and the coupling line electrode 58c, respectively, are provided on side surfaces of the first dielectric layer 51a, the second dielectric layer 51b, the third dielectric layer

51c, the fourth dielectric layer 51d, and the fifth dielectric layer 51e. The first shield electrode 52a and the second shield electrode 52b are connected by end face electrodes 60a and 60b.

5 A part 57a of the transmission line electrode 57 is overlapped with the coupling line electrode 58c with the third dielectric layer 51c interposed therebetween in a projection in a lamination direction. The width of the part 57a of the transmission line electrode 57 is different from that of the coupling line electrode 58c in the projection in the lamination direction.

10 According to the configuration of the present embodiment, the coupling line electrode 58c and the transmission line electrode 57 are placed in a vertical direction, so that electromagnetic field coupling becomes further stronger. Furthermore, the width of the part 57a of the transmission line electrode 57 is set to be different from that of the coupling line electrode 58c, whereby a margin can be provided with respect to a shift in overlapping  
15 during lamination. The width of the part 57a of the transmission line electrode 57 may be the same as that of the coupling line electrode 58c.

#### Embodiment 11

FIG. 22 is a schematic perspective view showing a laminate-type  
20 high-frequency device according to Embodiment 11 of the present invention. As shown in FIG. 22, the laminate-type high-frequency device according to the present embodiment includes a duplexer composed of a laminate 71 in which dielectric layers and electrode layers are laminated alternately. A semiconductor chip 72, a surface acoustic wave device 73, a PIN diode 74, a  
25 chip capacitor 75, and a chip resistor 76 are mounted on an upper surface of the laminate 71.

In the present embodiment, a duplexer having the configuration described in each of the above-mentioned embodiments is used. For example, a first filter for transmitting and a second filter for receiving having different  
30 pass band frequencies are provided in the laminate 71. A matching circuit composed of a coupling line, having one end that is short-circuited and the other end that is connected to an external terminal, is provided between the first and second filters. The first filter includes at least one first stripline resonator, having one end that is short-circuited. The second filter includes  
35 at least one second stripline resonator, having one end that is short-circuited. The first stripline resonator and the second stripline resonator are coupled to the coupling line by electromagnetic field coupling.

According to the configuration of the present embodiment, a duplexer can be realized with a very simple configuration. Therefore, a laminate-type high-frequency device can be obtained, in which a loss can be reduced substantially and which is provided with a semiconductor chip and/or a surface acoustic wave device.

#### Embodiment 12

FIG. 23 is a schematic view showing communication equipment according to Embodiment 12 of the present invention.

As shown in FIG. 23, communication equipment according to the present embodiment includes an antenna 85, and a duplexer 84 composed of a laminate in which dielectric layers and electrode layers are laminated alternately, for transmitting a frequency component output from a transmitting circuit to the antenna 85 and transmitting a frequency component received from the antenna 85 to a receiving circuit. The duplexer 84 is connected to a transmitting circuit portion 82 and a receiving circuit portion 83, and the transmitting circuit portion 82 and the receiving circuit portion 83 are connected to a base band portion 81.

As the duplexer 84, a duplexer having the configuration as described in each of the above-mentioned embodiments is used. For example, a first filter for transmitting and a second filter for receiving having different pass band frequencies are provided in a laminate. A matching circuit composed of a coupling line, having one end that is short-circuited and the other end that is connected to an external terminal, is provided between the first and second filters. The first filter includes at least one first stripline resonator, having one end that is short-circuited. The second filter includes at least one second stripline resonator, having one end that is short-circuited. The first stripline resonator and the second stripline resonator are connected to the coupling line by electromagnetic field coupling.

According to the configuration of the present embodiment, a duplexer can be realized with a very simple configuration. Therefore, communication equipment can be obtained, in which a loss can be reduced substantially.

As a variation of the present embodiment, a semiconductor chip and/or a surface acoustic wave device may be mounted on an upper surface of the laminate. According to this configuration, communication equipment can be obtained, including a laminate-type high-frequency device in which a loss can be reduced substantially and which is provided with a semiconductor



chip and/or a surface acoustic wave device.

5 The invention may be embodied in other forms without departing from the spirit or essential characteristics thereof. The embodiments disclosed in this application are to be considered in all respects as illustrative and not limiting. The scope of the invention is indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.